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EFFECTS OF A CHANGE IN THE CONTROL DEVICE ON INTERSECTION ACCIDENTS

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Joint Highway Research Project

PURDUE UNIVERSITY
LAFAYETTE INDIANA

by

G. W. SCHOENE
and
H. L. MICHAEL

EFFECTS OF A CHANGE IN THE CONTROL DEVICE
ON INTERSECTION ACCIDENTS

To: G. A. Leonards, Director
Joint Highway Research Project

December 19, 1966

File: 8-5-7

From: H. L. Michael, Associate Director
Joint Highway Research Project

Project: C-36-59G

The attached Technical Paper "Effects of a Change in the Control Device on Intersection Accidents" by G. W. Schoene and H. L. Michael is submitted for approval of publication in the Proceedings of the 1966 Annual Purdue Road School.

The paper is a summary of a research report previously reported to the Board. The paper basically includes the findings of a research project on changes in accident characteristics and numbers resulting from the installation of traffic signals at intersections with prior two-way stop control.

The report is presented to the Board for action on the publication request.

Very truly yours,

Harold L. Michael

Harold L. Michael
Associate Director

HLM:sr

Attachment

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W. H. Goetz
W. L. Grecco
G. K. Hallock
F. S. Hill
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Technical Paper

EFFECTS OF A CHANGE IN THE CONTROL DEVICE ON INTERSECTION ACCIDENTS

by

G. W. Schoene, Graduate Assistant

and

H. L. Michael, Associate Director

Joint Highway Research Project

File No: 8-5-7

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Purdue University

Lafayette, Indiana

December 19, 1966

EFFECTS OF A CHANGE IN THE CONTROL DEVICE ON INTERSECTION ACCIDENTS

INTRODUCTION

In recent years vehicular travel has been increasing at a tremendous rate. The growth of traffic volumes at many intersections has necessitated many changes in the control devices employed to regulate the intersecting traffic flows. The control devices most often used when the volumes are low are stop or yield signs. At high volume at-grade intersections, however, a traffic signal is required to regulate the intersecting traffic flows to reduce congestion and delay.

Since the traffic signal is the control device employed to regulate traffic at high-volume intersections, it has been assumed by much of the motoring public to be a cure-all for intersection problems, including safety. It was the purpose of this research to provide traffic officials with factual information about possible changes in accident characteristics which might occur when a traffic signal replaced two-way stop control.

PROCEDURE AND ANALYSES

The before and after study technique was chosen as the method to be used for this research. It was, therefore, necessary to select signalized intersections for which good historical accident data were available, to collect intersection physical and traffic data for both the before and after periods, to collect pertinent information about the accidents occurring at each intersection for a period of time both before and after the installation of a signal, and then to compare and analyze the characteristics of the before signalization accidents with the characteristics of the after signalization accidents.

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Selection of Intersections

In selecting the intersections to be used in this research, a sample of intersections was desired which were similar for design and location characteristics so as to minimize accident causation variables between intersections. A set of criteria was developed and used in selecting the sample intersections. These criteria were:

1. Accident histories for each intersection must be available for approximately two years both before and after the date of signal installation.
2. There should not be another control device or railroad crossing within two blocks of the study intersection.
3. There should not have been any major construction at the intersection from the beginning to the end of the intersection study period.
4. The intersection must have four approaches, the opposing approaches not being offset, and the angle between the approaches should be about 90 degrees.
5. The vision of the control device by the driver should not be obstructed.
6. The intersection should not be on or near a significant verticle or horizontal curve.

Collection of Volume Data

Almost all accident studies indicate that traffic volume and accidents are correlated. In this study, traffic volume and the control device were important characteristics of each intersection which changed during the study period.

Because the signal installations had been made several years, 1956 thru 1963, prior to this study, it was not always possible to obtain counts of the average daily traffic volume using each intersection at the time of signalization. Turning movement counts that were often made prior to signal installations, twenty-four hour counts of the traffic volumes on major roads throughout the state, and monthly, daily, and area factors that are used to convert twenty-four hour weekday counts into average daily traffic (ADT) counts were used to develop an estimate of the traffic volume using each intersection during the before and after signalization periods.

The ADT entering the sample intersections on the major and minor streets ranged from 3000 to 21,000 vehicles and from 700 to 6300 vehicles, respectively, when the intersections were signalized. The average sum of the two intersecting volumes for all intersections was 13,100 vehicles per day.

Collection of Accident Data

The files of the reports of traffic accidents maintained by the Indiana State Police served as the primary source of accident data. Other sources of accident data were the local police and traffic departments of the cities in which the intersections were located.

Accident data were collected from the accident reports on all accidents which occurred at each sample intersection or within 200 feet of the intersection (14).* Such data were obtained for a period of approximately twenty-four months before the signal installation and for an equal time period after signalization. The choice of twenty-four months

* Numbers in parenthesis refer to numbers in the Bibliography.

for the before and after signalization time periods was a compromise between having insufficient data if a shorter period of time were used, and having increased expense or fewer intersections available for study if a longer period of time were used. The before and after time periods ranged from thirty-one to fifteen months, with most intersections having exactly twenty-four month before and after time periods.

Since traffic volumes increased during the study periods, some adjustment to the numbers of accidents occurring before signalization was made in order to compare such numbers with those occurring after signalization. The method used for this adjustment was to multiply the number of accidents occurring during the before period by the intersection ratio of the total average daily volume of traffic entering the intersection during the after period to the total average daily volume of traffic entering the intersection during the before period. The resulting adjusted number of before accidents was used for all before and after signalization accident comparisons. The after to before entering volume ratio was used because no better accident-volume relationship could be determined and it was simple and logical.

Comparison of Accident Occurrence

Accident occurrence was considered to be a measure of intersection safety. Therefore, a comparison was made between the adjusted numbers of before accidents and the numbers of after accidents at each sample intersection. This comparison was made for the total number of accidents and for several types of accidents, right-angle accidents, rear-end accidents, and other or miscellaneous accidents.

As was expected, almost all intersections experienced a change in the absolute numbers of accidents. This finding was true for the total accidents as well as the specific types of accidents (see Table 1).

the obvious modes of accidents. This finding was true for the total accidents as well as the specific types of accidents (see Table 4).

Table 1. Percentage of Intersections Having an Absolute Change in Accident Numbers From Before to After Signalization.

Total Accidents	
Increase	53
No Change	3
Decrease	44
Right-angle Accidents	
Increase	31
No Change	3
Decrease	66
Rear-end Accidents	
Increase	78
No Change	19
Decrease	3
Miscellaneous Accidents	
Increase	50
No Change	28
Decrease	22

Because almost all intersections had a change in the absolute numbers of accidents from before to after, it was necessary to determine if the absolute difference in the numbers of accidents was greater than that expected by chance alone. To make this determination it was necessary to test the hypothesis that the numbers of accidents were statistically identical.

For this test of hypothesis it was assumed that accident occurrence has a Poisson distribution. The test of hypothesis was that the mean of the Poisson distribution is the same after signalization as before. It was further assumed that the number of adjusted before accidents was the true value. The number of after accidents was then compared to this constant value.

The first question asked when evaluating this hypothesis was:

Was there a significant change in the numbers of accidents?

From a review of the results shown in Table 2, it is immediately obvious that a large number of the intersections did not have a difference in the number of accidents from before to after that was great enough to be considered statistically significant. This finding is important, but equally important is the fact that for those intersections which had a change in the number of accidents large enough to be considered significant, the change was either an increase as for rear-end accidents or a decrease as for right-angle accidents.

The total number of accidents (see Table 1) increased at slightly more than half of the intersections while decreasing at slightly less than half. This increase or decrease, however, was significant at only about one half of the intersections (Table 2). When the change was significant, it was more often an increase than a decrease and the effect on the type

Table 2. Percentage of Intersections Having a Significant Change in the Number of Accidents From Before to After Signalization.

Total Accidents	
Significant increase	34
No significant change	44
Significant decrease	22
Right-angle Accidents	
Significant increase	16
No significant change	40
Significant decrease	44
Rear-end Accidents	
Significant increase	66
No significant change	34
Significant decrease	0
Miscellaneous Accidents	
Significant increase	25
No significant change	69
Significant decrease	6

of accident, moreover, is also important. Where significant changes occurred, the number of right-angle accidents usually decreased while rear-end and miscellaneous accidents increased. The changes in numbers of accidents expressed in general values were as follows:

1. Right-angle accidents decreased at two-thirds of the intersections while increasing at only one-third.
2. Rear-end accidents increased at three-fourths of the intersections, and decreased at only one intersection.
3. Miscellaneous accidents increased at half of the intersections while decreasing at only one-fourth.

Comparison of Injury Accident Occurrence

Whether or not an injury occurred in an accident is also a measure of the severity of the accident and was investigated in this study. If the investigating officer indicated on the accident report form that a person was injured or killed, such accident was considered to be an injury one. An injury is this study, therefore, included everything from a reported complaint of injury or a scratch to a fatality.

By dividing total accidents at each intersection into injury and non-injury, and similarly for right-angle, rear-end, and miscellaneous accidents, the numbers of accidents which were injury for before and after periods were compared by using the same techniques previously employed. The results are shown in Table 3.

Most of the intersections did not have a significant change in the number of total accidents which were injury. This finding was also true for right-angle, rear-end, and miscellaneous accidents. However, for those intersections having a significant change, the change was usually an increase in the number of total, rear-end, and miscellaneous accidents.

Table 3. Percentage of Intersections Having a Significant Change in the Number of Injury Accidents From Before to After Signalization.

Total Accidents	
Significant increase	38
No significant change	50
Significant decrease	12
Right-angle Accidents	
Significant increase	16
No significant change	68
Significant decrease	16
Rear-end Accidents	
Significant increase	28
No significant change	72
Significant decrease	0
Miscellaneous Accidents	
Significant increase	16
No significant change	84
Significant decrease	0

Comparison of Total Property Damage Costs

Total property damage accident costs increased at 56 percent of the intersections from before, with two-way stops, to after, with signalization (see Table 4). The percentages of intersections having an increase in accident property damage costs were similar to the percentages of intersections having an increase in accidents (see Table 1). The linear correlation coefficients between total accidents and total property damage costs were 0.83 and 0.86 for before and after signalization, respectively. Since total accidents and total property damage costs were correlated, and if the number of accidents did not change significantly at an intersection, no significant change in the total property damage costs could be expected.

Changes in Accidents Correlated with Pretimed Signal Warrants

Since the warrants for pretimed traffic signals (as stated in the Manual on Uniform Traffic Control Devices) are widely used by traffic officials when investigating the request for a traffic signal, it was decided to group the intersections of this study with respect to meeting (Group 1) or not meeting (Group 2) these warrants. A third group (Group 3) of intersections, composed of some intersections from the other two groups, was also formed. These latter intersections had five or more accidents during the twelve months preceding signalization of the type, right angle accidents, often considered correctible by a signal.

Each intersection within these groups was then analyzed by comparing major street volume with the larger minor street entering volume. An indication was also noted in this analysis of the extent of the change in the total accident pattern after signalization (significant increase, absolute increase, no change, absolute decrease, or significant decrease).

Table 4. Percentage of Intersections Having an Increase in the Total Property Damage Costs for the Indicated Accident Pattern.

Accident Pattern	Percent of Intersections
Total Accidents	56
Right-angle accidents	34
Rear-end accidents	72
Miscellaneous accidents	66

The findings of this analysis for those intersections that met the warrants (Group 1) were that such intersections had a tendency to have:

1. A significant increase in total accidents if the ratio of the major street entering volume (both directions) to the larger minor street entering volume (one direction) was greater than four to one.
2. No significant change in total accidents if the ratio of major street entering volume to the larger minor street entering volume was less than four to one.

A decrease in accidents, however, did occur at five of the twelve intersections in this group. Two of these intersections had a significant decrease. Most of the intersections which had a decrease in accidents after signalization had a significant decrease in right-angle accidents. For most of these intersections the number of right-angle accidents for the two year before period was greater than ten and as high as 25. Almost every intersection which had an increase in accidents in the after period had less than ten right-angle accidents in the two year before period.

Even though each of the twelve intersections in Group 1 met the MUTCD volume warrants for the installation of a signal, seven had an increase in accidents. This increase was significant at four. It would appear that one can expect accidents to increase after signalization under current warrants if the ratio of total major street entering volume to larger minor street entering volume is greater than four to one unless there are at least five or more correctible, right-angle, accidents per year.

Those intersections which did not meet the warrants (Group 2) had the following volume characteristics: Almost all of the intersections having more than 8000 entering vehicles per day on the major street had

less than 2000 entering vehicles per day on the larger minor street approach. This situation occurred because almost every signalized intersection in the state with high major street values and minor street volumes greater than 2000 had been signalized prior to the study periods of this research.

The intersections in Group 2 tended to have:

1. An increase in total accidents if the ratio of the entering volume on the major street (both directions) to that on the larger minor street (one direction) was greater than six to one.
2. Little change or a decrease in accidents if the ratio of the entering volume on the major street to that on the larger minor street was less than six to one.

Some exceptions to the above rules were evident, however, Again the factor of a large number of right-angle accidents prior to signalization appeared to be important for those intersections which had a decrease in accidents and which had an ADT of over 8000 vehicles on the major street. For low volume intersections in this group (less than 8000 vehicles per day on the major street), an increase in accidents after signalization occurred at only four out of thirteen intersections; at two of these four it was significant. Most of these intersections had less than ten accidents prior to signalization and apparently because of the low traffic volumes, did not usually experience an increase after signalization. It would appear that the installation of traffic signals at intersections where the traffic volume is low (below 8000 vehicles per day) on the major street will not usually result in an increase in accidents.

Those intersections in Group 3 that had five or more accidents of the type correctible by a signal (right-angle) within the twelve months

preceding signalization tended to have a decrease in total accidents. This decrease was significant for those intersections with a major street ADT of less than 8000 vehicles. The decrease was usually due to a significant decrease in right-angle accidents. For the higher volume intersections (major street ADT greater than 8000 vehicles) there often was, however, a significant increase in rear-end accidents, thus overshadowing the significant decrease in right-angle accidents.

Comparisons of Accident Characteristics with the Data Grouped

Because one or two spectacular accidents at an intersection may distort the accident severity picture, the accident data for the before periods of all intersections were combined. Likewise, the data of the after periods were combined. The combined data were then compared. Validity of results from comparisons of the data grouped in this manner depend upon the following additional assumptions. The probability of an accident with given characteristics was assumed to be the same at all the studied intersections for both the before and after periods. The sampled intersections were considered to be representative of all intersections which had recently been signalized.

The ratios of all fatal accidents to all injury accidents to all property damage accidents are often used as a measure of accident severity. The ratios were 1:21:63 for the intersections with the two-way stops and 1:30:81 for the same intersections after signalization.

The total number of accidents occurring is also a measure of the accident problem. Table 5 presents the summation of the accidents occurring at all the sample intersections. The values in Table 5 indicate that the total number of accidents increased after the intersections were signalized. This increase in total accidents usually resulted from increases

in rear-end and miscellaneous accidents overshadowing a decrease in right-angle accidents.

By a knowledge of the number of accidents that had an injury or fatality (Table 6), it was possible to calculate the percentage of accidents which were injury (see Table 7).

The increase in the percentages of right-angle accidents which were injury was probably due to an increase in the number of drivers that did not obey the control device. With two-way stops only the minor street traffic could not obey the control device. With signals, part of the major street traffic along with part of the minor street traffic, the sum being greater than the minor street traffic volume, had the opportunity not to obey the control device. The increase in the severity of rear-end accidents, as well as the large increase in their numbers, was probably due to the many additional stops required of the higher speed traffic on the major street after signalization.

Property damage costs are another measure of intersection accident severity.

The total property damage cost of total accidents increased after signalization. Total right-angle property damage cost decreased while rear-end and miscellaneous property damage costs increased after signalization.

CONCLUSIONS

Under current practices in Indiana, the installation of traffic signals at an intersection did not usually result in fewer accidents occurring at that intersection. In fact, a large proportion of the intersections did not have a change in the number of accidents from before to after signalization that was great enough to be considered statistically significant. For those

Table 5. Changes in the Numbers of Accidents. Before to After Signalization

Accident Pattern	Adjusted Before	After	Percent Change
Total Accidents	388	451	+ 16
Right-angle accidents	201	105	- 48
Rear-end accidents	53	170	+221
Miscellaneous accidents	134	176	+ 31

Table Table 6. Changes in the Numbers of Fatal and Injury Accidents. Before to After Signalization.

Accident Pattern	Adjusted Before	After	Percent Change
Total Accidents	100	126	+ 26
Right-angle accidents	69	46	- 33
Rear-end accidents	7	42	+500
Miscellaneous accidents	24	37	+ 54

Table 7. Changes in the Percentages of Accidents that were Fatal or Injury Accidents. Before to After Signalization.

Accident Pattern	Before	After
Total Accidents	23	28
Right-angle accidents	34	44
Rear-end accidents	13	25
Miscellaneous accidents	18	22

intersections which did have a change in the number of the various accident types large enough to be considered significant, the change was usually an increase in total, rear-end and miscellaneous accidents and a decrease in right-angle accidents.

A change in the composition of the total number of accidents was typical (see Figures 1 through 5). Right-angle accidents normally decreased, while rear-end accidents increased. The remaining or miscellaneous accidents increased more often than they decreased. The usual increase in rear-end accidents sometimes overshadowed the usual decrease in right-angle accidents and an increase in total accidents occurred. On the other hand, when there were five or more right-angle accidents per year prior to signalization, the increase in rear-end accidents was not usually large enough to overshadow the decrease in right-angle accidents and a decrease or no change in total accidents occurred.

The severity of the overall accident problem did not change at most intersections as most intersections had no significant change in the number of total accidents, the number of accidents which were injury and the amount of the property damage cost. When there was a significant change in these accident characteristics at an intersection, the trend was an increase.

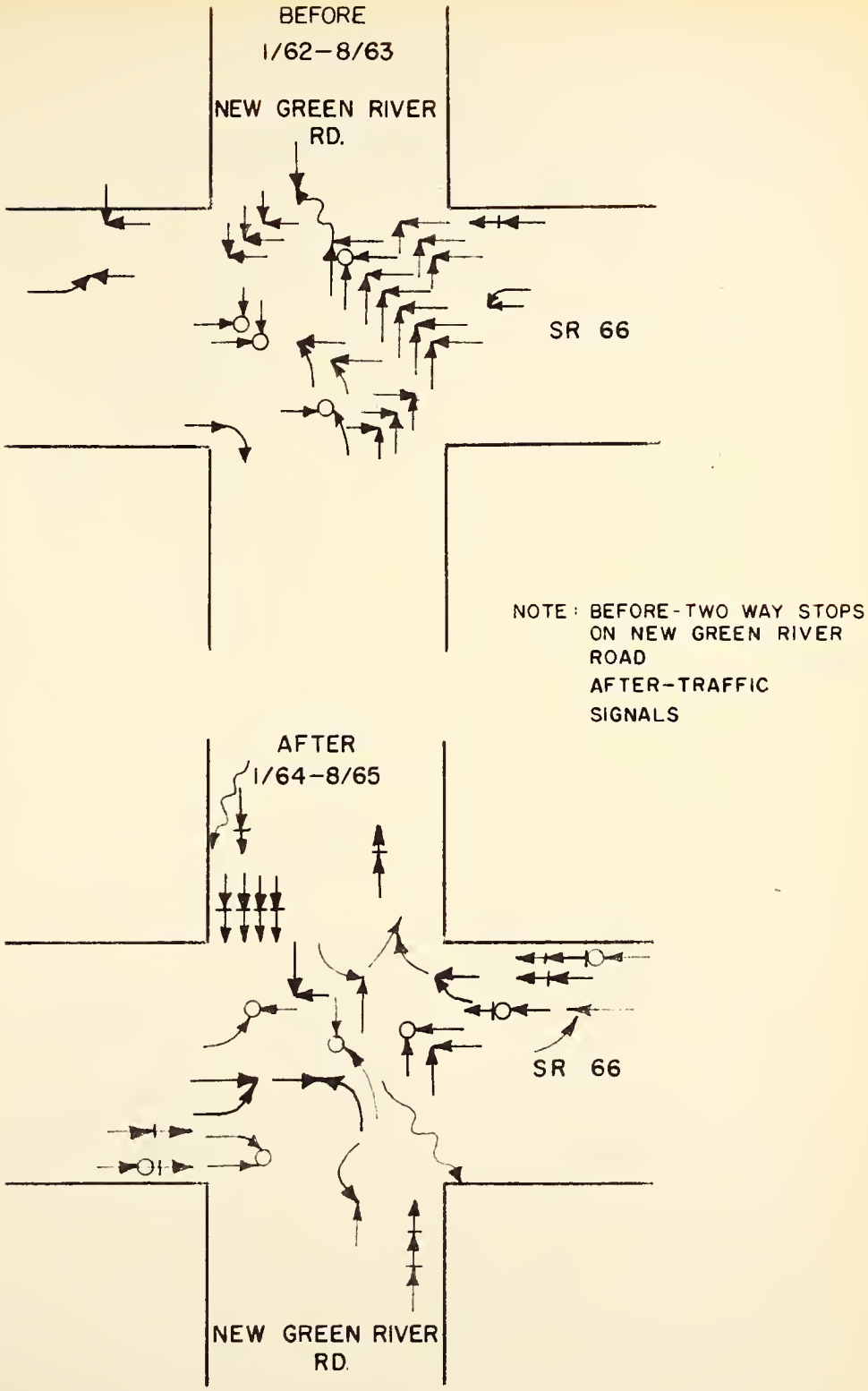

FIGURE 1. COLLISION DIAGRAM FOR SR 66 & NEW GREEN RIVER ROAD (INTERSECTION 2)

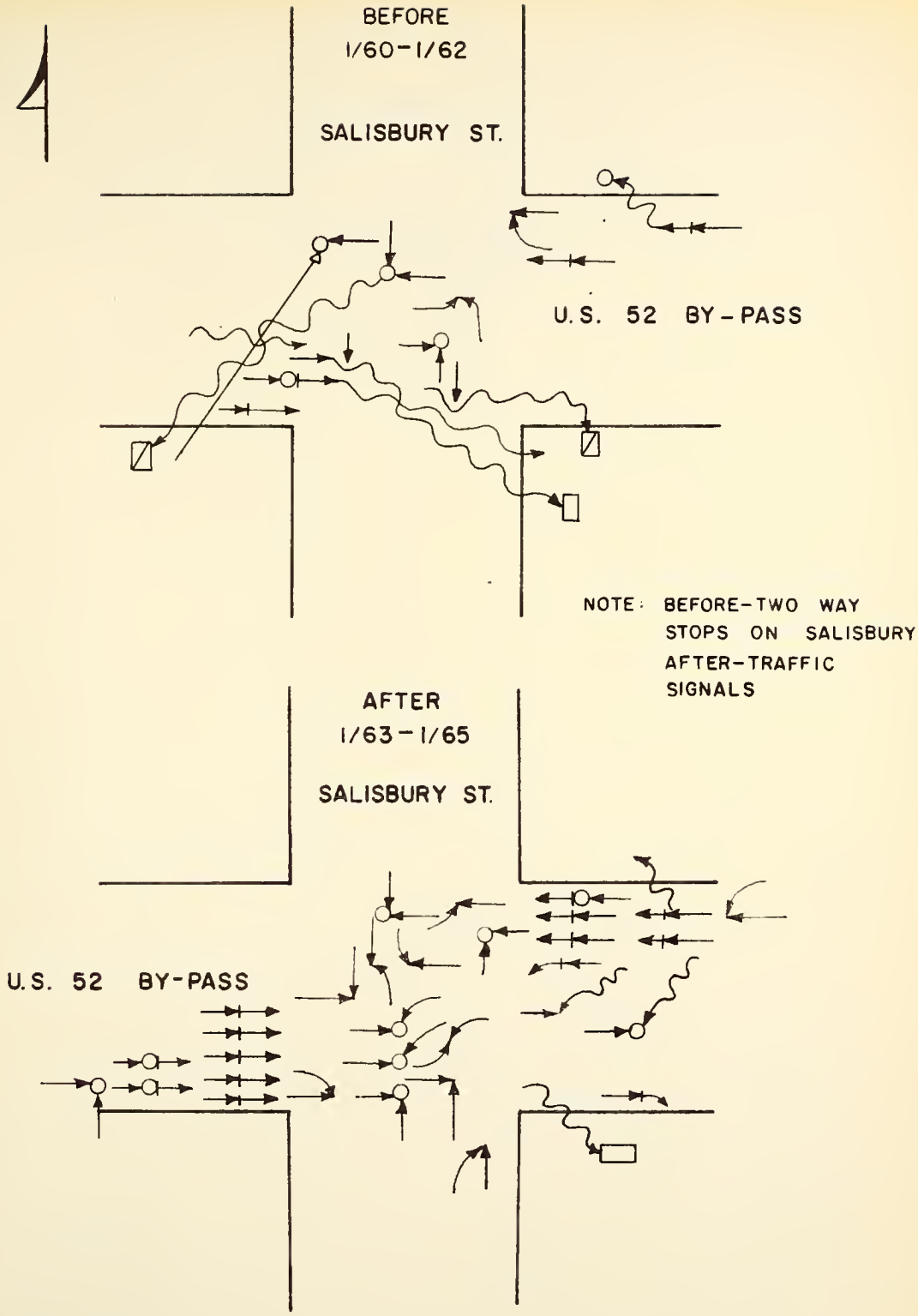

FIGURE 2. COLLISION DIAGRAM FOR U.S. 52 BY-PASS & SALISBURY STREET (INTERSECTION 6)

4

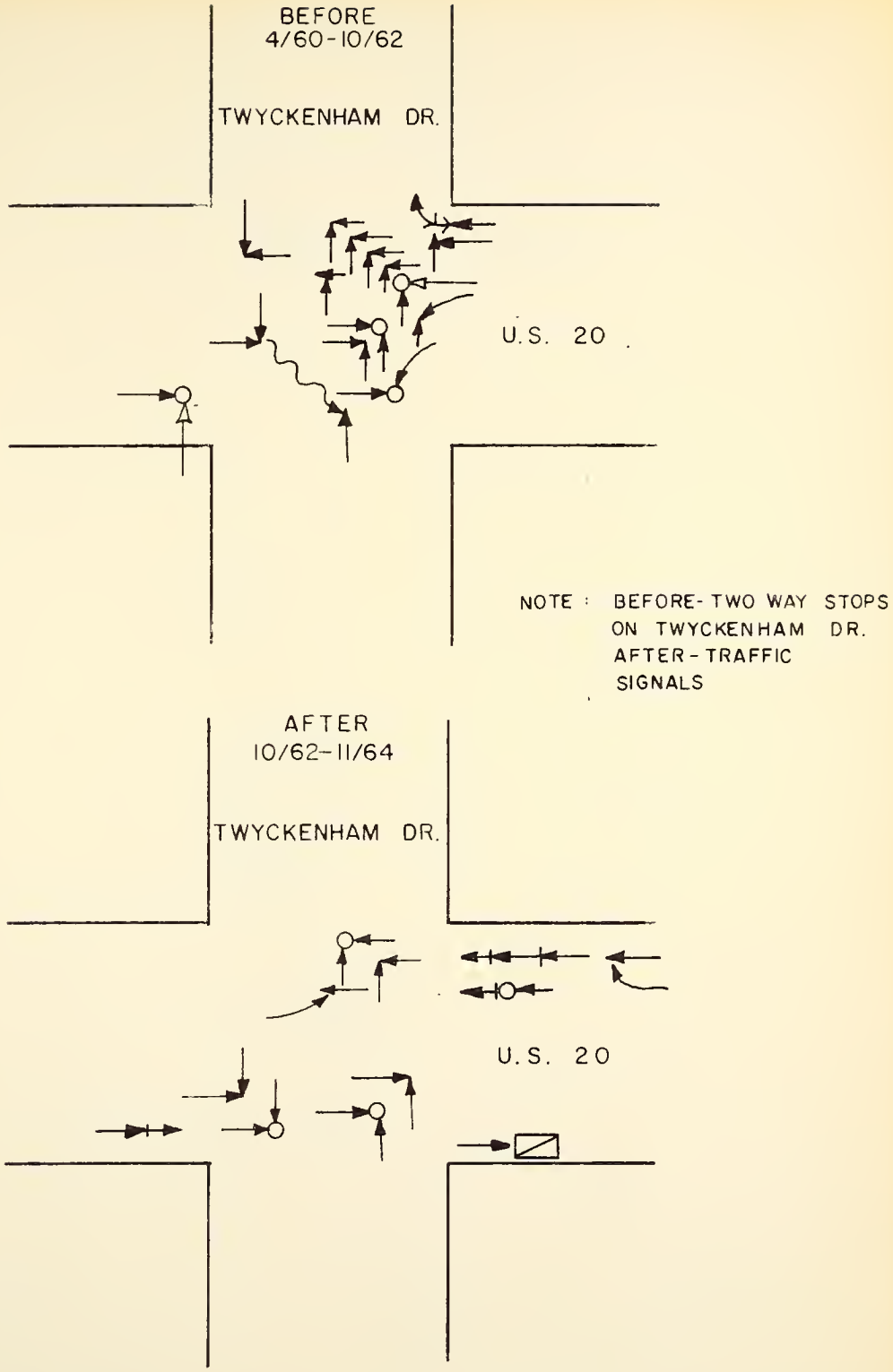

FIGURE 3. COLLISION DIAGRAM FOR U.S. 20 & TWYCKENHAM DRIVE (INTERSECTION 7)

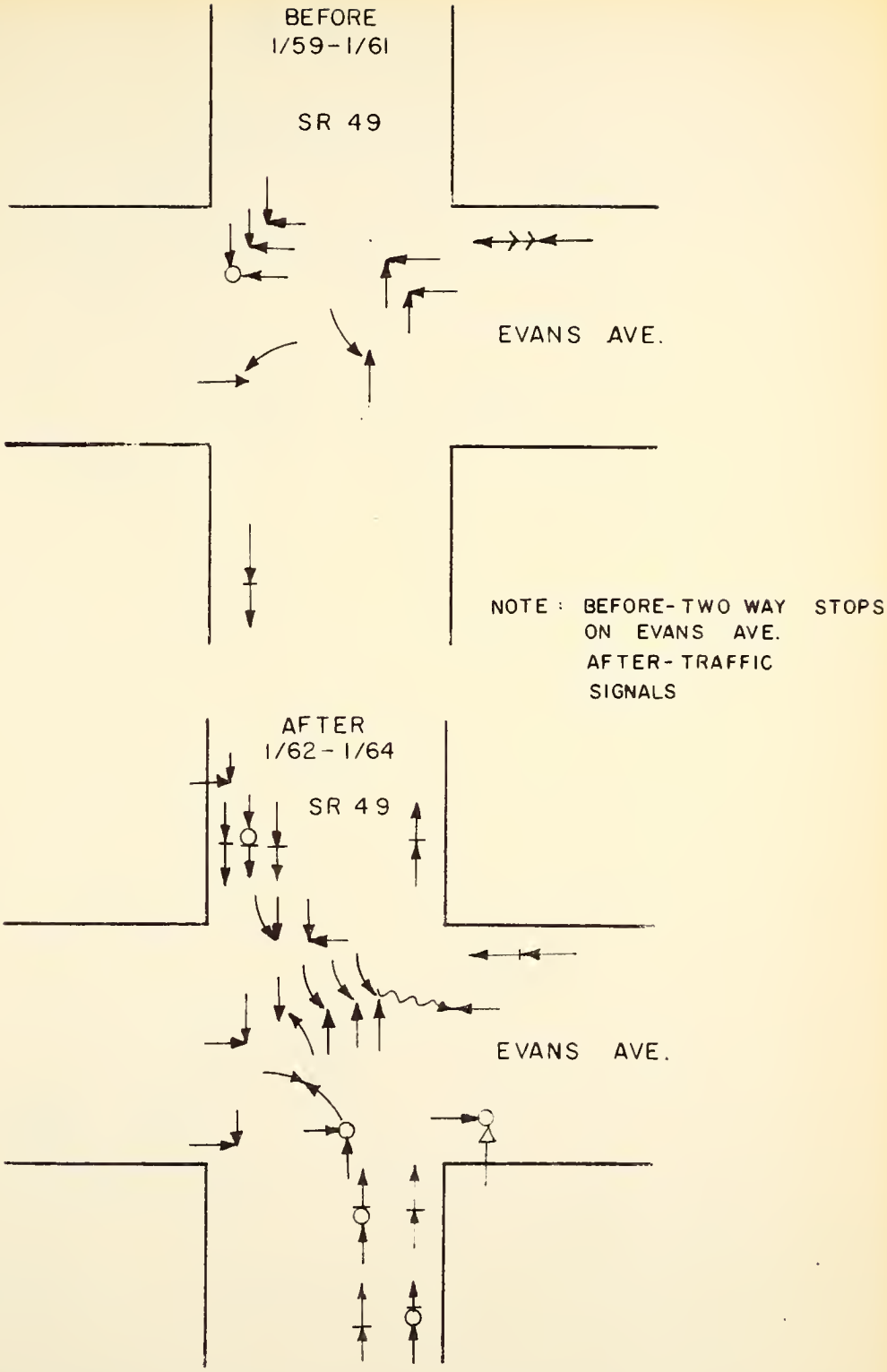

FIGURE 4. COLLISION DIAGRAM FOR SR 49 & EVANS AVENUE (INTERSECTION 16)

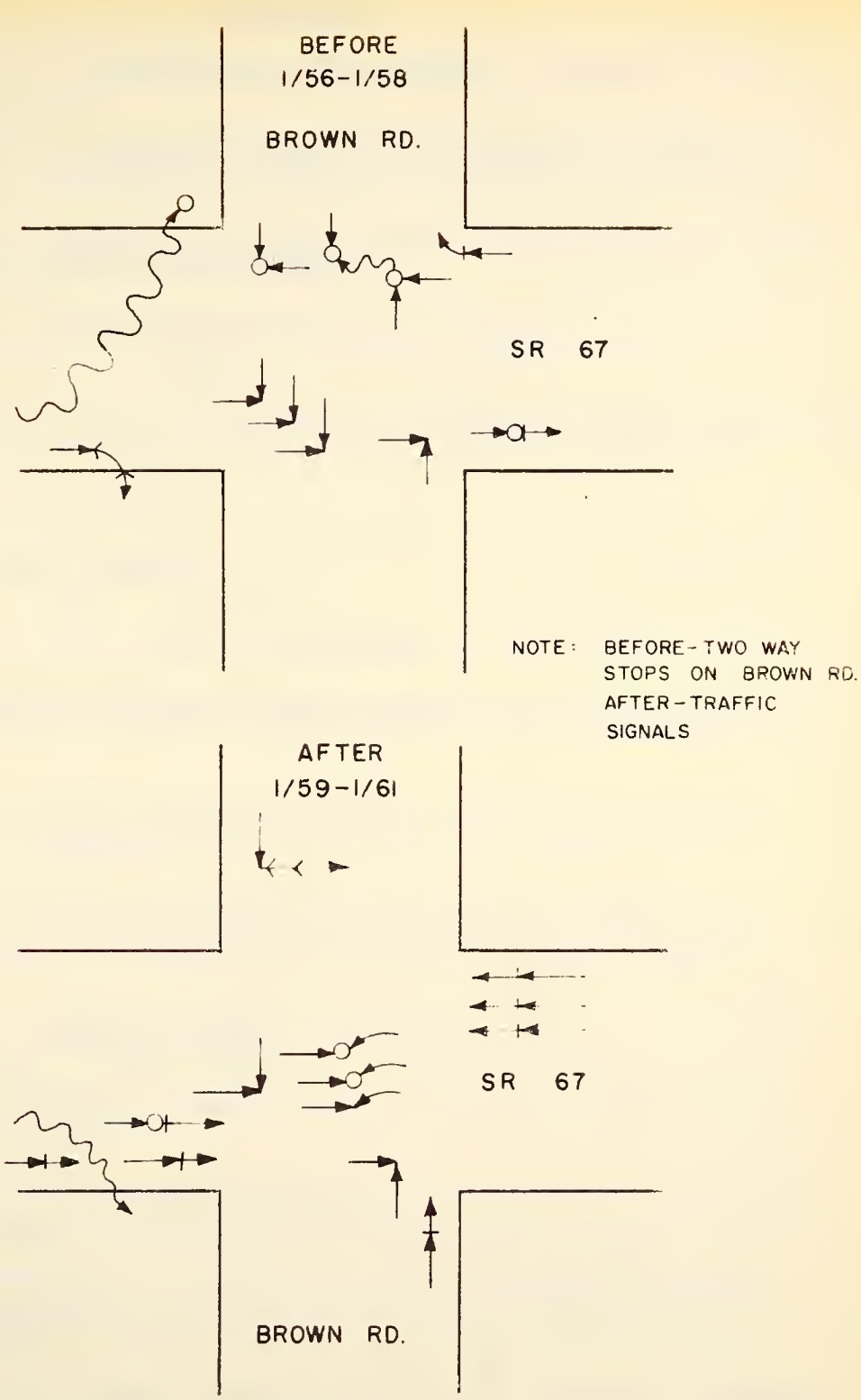

FIGURE 5. COLLISION DIAGRAM FOR SR 67 & BROWN ROAD (INTERSECTION 32)

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